No. 630, October term, 1930. DeForest Radio Company, petitioner, *v.* General Electric Company. Ordered, that the opinion in this case be amended as follows:

(1) By substituting for the words "In July, 1912," in the 12th line of the last paragraph of the opinion, the following:

"August 20, 1912, the earliest date claimed for Langmuir, was rejected, rightly, we think, by the District Court, which held that Langmuir was anticipated by Arnold in November, 1912. But before the earlier date,"

(2) By substituting for the 3d sentence from the end of the opinion the following:

"By August, 1912, the Telegraph Company used De Forest amplifying audions at 54 volts, and, by November, they were used by another at 67½ volts. This was possible only because the tubes had thus been exhausted of gas which would otherwise have ionized with blue glow at from 20 to 30 volts."

SUPREME COURT OF THE UNITED STATES.

No. 630.—October Term, 1930.

De Forest Radio Company, Petitioner,
vs.
General Electric Company.

On Writ of Certiorari to the United States Circuit Court of Appeals for the Third Circuit.

[May 25, 1931.]

Mr. Justice Stone delivered the opinion of the Court.

Certiorari was granted, 282 U. S. 836, to review a judgment of the Court of Appeals for the Third Circuit, holding the Langmuir Patent, #1,558,436, granted October 20, 1925, for "electrical discharge apparatus and process of preparing and using the same", valid, and infringed by petitioners. The District Court for Delaware, in which respondent, the assignee of the patent, brought suit for infringement, held the patent invalid for want of invention, and because of prior use and prior invention, and gave judgment dismissing the complaint, 23 F. (2d) 696, which the Appellate Court at first affirmed, and then, on reargument, reversed. 44 F. (2d) 931.

Infringement is conceded if the claims of the patent are valid. It is known as a high vacuum tube patent, and the alleged invention is exemplified in high vacuum tubes of familiar use as detectors of amplifiers in the art of radio communication and telephony. Correct appreciation of the contentions made requires, at the outset, an understanding and some exposition of the scientific principles which it is agreed are brought into play in the high vacuum tube or which at least are accepted as working hypotheses accounting for its operation.

A radio tube of the audion or three electrode type consists of a bulb, within which a vacuum has been created, enclosing a filament, which is a negative electrode, or cathode; a plate, which is a positive electrode, or anode; and a third electrode, known as a grid, located between the filament and the plate. The grid is connected with an input circuit, over which electrical radio activity, actuated

at the sending station, is gathered from the ether and passes to the grid. When the tube is used as an amplifier, the plate is connected in circuit with a telephone receiver or loud speaker. In operation, the filament is heated to incandescence by passing an electric current through it. In its incandescent state, electrons, or negative charges of electricity, are developed at the filament and pass to the plate, attracted to it by its positive potential, and cause a flow of electricity through the plate-loud-speaker circuit. The sounds given out by the loud speaker are produced by variations in the current passing to it. Radio amplification depends on producing in the more powerful current of the loud speaker circuit, variations exactly corresponding to the variations in the weaker input or voice current which are actuated by the sending station.

In the vacuum tube of the three electrode type, this is accomplished by passing the input or voice current over the grid. Variations in that current produce variations in potential of the grid which, by reason of its location between the filament and plate, effects like variations in the effective potential of the plate with corresponding variations in the loud speaker circuit. The number of electrons emitted by the filament is determined by its temperature. But the current passing through the plate loud speaker circuit depends on the number of electrons drawn from the filament to the plate, and this in turn depends on the voltage of the current passing to the filament. When it is high enough to force all the electrons emitted by the filament to pass from filament to plate, increase in the voltage at the filament will not produce an increase in current in the loud speaker circuit and the tube is then said to be "saturated". As successful operation of the tube depends on the response of the loud speaker current to changes in voltage effected by the voice or input current, the tube is most efficiently operated at a voltage of a range below saturation, and a current within this range is known as the "space current".

Of critical importance in the present controversy is the effect of the presence of gas within the tube. As in the practical art of bulb manufacture no scientifically perfect vacuum can be attained, air or other gas is always present within the vacuum tube. This consists of a small amount of residual gas, after the vacuum is created by pumping out the tube in the process of manufacture. There is also gas in the walls of the bulb and the electrodes, de-

scribed as "occluded," which, if not expelled from them and removed in the course of manufacture, is later freed in varying amounts when the tube is in use, by the action of the heat of the filament and the electrons generated there.

The passage of electrons from filament to plate at certain voltages produces changes in the gas, known as "ionization". Ionization is the manifestation of a rearrangement of the constituent electrons of the gas atoms which occurs, in low vacuum tubes, if other factors of causation remain constant, at known voltages within a range of from 20 to 30, but varying somewhat with different gases. The atom, according to present day scientific theory, is composed of an electrically positive nucleus, around which revolve at high speeds electrically negative electrons. In its normal state, the atom, whose nucleus and electrons are in electrical balance, exhibits no electrical effects; but within a thermionic tube, the impact upon the gas atoms of the electrons, passing from cathode to anode at velocities induced by ionization voltages, forces off negative electrons from the atoms. The atoms from which the electrons have thus been detached are then electrically positive and are known as ions. Ionization, which begins at the ionization voltage, is increased with increasing voltages as the tube approaches saturation, when extreme ionization takes place; and, for reasons which need not be elaborated here, the tube then ceases to function as a radio tube, a condition visibly manifested by a blue glow within it.

Gas ionization in the vacuum tube is of great practical importance because of its effect on the current passing from filament to plate. Ionization, when it occurs, may operate within the range of the space current to increase "conductivity" of the tube, that is, the discharge from filament to plate, above what it would be at the same voltage in the absence of ionization, through the development of the positive ions, which pass to the cathode, and of the negative electrons, which pass to the anode. The ions facilitate the flow of electrons from cathode to anode and increase their number by impact on the former, which raises its temperature. The result is that, in low vacuum tubes, saturation with the blue glow effect is reached, other factors remaining constant, at lower voltages than in high vacuum tubes. Hence, in the range of voltage above ionization and below saturation, within which the tube is commonly

operated, a low vacuum tube, because of the increase of current due to ionization, is more responsive to slight changes in voltage produced by the operation of the grid or input current. In consequence, the low vacuum tube is more sensitive both as a detector and as an amplifier than a tube of high vacuum.

But this advantage is accompanied by a serious disadvantage, especially when the tube is used for amplification, in that ionization produces variations in the electronic discharge from filament to plate, which correspondingly affect the current passing through the loud speaker circuit. Ionization is affected by the amount of gas in the tube, and hence by the degree of vacuum and the amount of occluded gas freed in operation by heat and bombardment. Since the discharge varies with the amount of ionization, the effective current in the loud speaker circuit varies with different tubes and with the same tube at different times; and critical adjustments of the current flowing to the filament are necessary to improve operation.

From what has been said, it is apparent that the problem of securing evenness or regularity of discharge from filament to plate and hence of current flowing through the loud speaker circuit is dependent upon the reduction of ionization in the tube, and this in turn is dependent, within certain ranges of limits, upon a number of variables, the more important of which are (1) the geometry of the tube, that is, its size and shape and the location of electrodes, (2) heat of the filament, (3) voltage of the filament, and (4) of vital importance here, amount of gas, that is, pressure within the tube. With the other variables controlled so as to remain approximately constant, as is practicable, reduction of pressure reduces ionization and increases steadiness of current and in turn raises the saturation point of the tube, permitting its use with higher than ionization voltages.

As in the low vacuum tube regularity or evenness of the loud speaker current was more or less imperfectly secured by varying the voltage at the filament with different tubes and at different times with the same tube, the desired result may also be attained, and far more effectively, by reducing the pressure in the tube and keeping other factors constant. When a vacuum is produced of as low a pressure as a few hundredths of a micron (a micron is equal to 1/1000 of a millimeter of mercury in terms of barometric

pressure), the discharge is independent of the degree of vacuum, when the tube is used with appropriate space charge. The discharge then passing from cathode at constant temperature to anode, varies directly with the 3/2 power (square root of the cube) of the voltage imposed on the cathode. This is equivalent to saying that steadiness of current through the loud speaker circuit is obtained, with an increase in power, until saturation, in known relationship to the increase of the imposed voltage. While the effectiveness of the low vacuum tube begins to diminish, in the upper range of ionization voltages, with high vacuum tubes, currents of much higher voltages may be used without loss of effectiveness.

The desired reduction of pressure in the tube involves the use of methods for producing a high vacuum and reducing to a minimum the effects of occluded gas. By evacuating the tube by pump or other suitable means, and at the same time freeing it of occluded gas by heating tube and electrodes, and also, as may be done, by passing a current through the filament, causing "bombardment" of the electrodes by electrons, a high vacuum tube is produced. By such procedure, the disturbing influence of ionization may be removed with consequent stability of discharge. The result is of great importance, since by adaptation of the procedure to manufacturing methods, tubes giving uniform stability of current may be commercially produced, suitable for use in the complex modern radio receiving sets employing multiple tubes, without necessity for the critical adjustments of the filament circuit necessary with low vacuum tubes.

It is the high vacuum tube of this type which respondent says embodies the Langmuir invention. As a product or structure it differs from the low vacuum tube, of which the Fleming valve and De Forest audion are well known types, only in that the pressure has been reduced to such a point that there is no appreciable ionization, with the resulting constancy of current in the amplifier circuit.

In the light of the explanation given of the operation of the vacuum tube, we now examine the claims of the patent. The application, filed October 16, 1913, was pending for twelve years before it was issued October 20, 1925, a period which witnessed the most important beginnings and many of the chief developments of the radio art. The original application was for a process or method patent only. It contained five claims covering methods of obtaining

a high vacuum in vacuum tubes and expelling occluded gas from them. These claims were all ultimately cancelled. Other process claims, substituted by amendment, of which four only survived in the patent as issued, were amplifications of the original method and process claims. Late in 1913 Langmuir first made claim to invention of the tube as a structure or device, in four claims, all of which were amended one or more times. All but the third, which was amended four times, were cancelled in 1925, the year the patent issued. There are twenty-eight claims for the structure or device in the patent as issued. Of these one was filed by amendment in 1913, one in 1917, nine in 1919, three in 1921, and fourteen in 1925. During the twelve years the patent was pending, there were sixty-seven amendments of specifications, of which forty-five were in 1925. Amended claims filed, and additions and cancellations of them made, number one hundred in all, of which forty-two were in 1925.

The process claims cover methods of creating the high vacuum tube in the manner already described, that is, freeing the tube of occluded gas by heating tubes and electrodes and by electronic bombardment, at the same time evacuating the tube of air or gas by approved methods, such as the use of the Gaede molecular pump or chemical means. The court below did not rest its holding of validity of the patent on these claims, and respondent does not seriously urge their validity here. It suffices to say that an examination of the prior art discloses that long before the earliest date claimed for Langmuir, the necessity for removing occluded gas from tubes or other electrical discharge devices in order to procure a high vacuum, and the methods of doing it by heating and electronic bombardment were well known, as was the procedure for constructing the high vacuum tube by expelling occluded gas while evacuating the tube. An article by Duncan, American Electrician, May, 1896; one by Doane, Electrical World and Engineer, of May 21, 1904; the Dwyer Patent, No. 496,694, January 4, 1898, for a process for producing high vacuum in incandescent lamps or similar receptacles during their manufacture; the Soddy Patent, No. 859,021, July 2, 1907, for the employment of certain reagents in the process of producing high vacuum; the Thatcher Patent, No. 1,028,636, June 4, 1912, application filed March 30, 1910, for method of exhausting vessels; and an article by Lilien-

field in 1910, to be mentioned later, disclosed before Langmuir the essentials for producing a high vacuum, described in the present process claims. They were in use in laboratory practice by Millikan and others before 1911.

It was upon the claims for the high vacuum tube structure or device that the court below based its decision, and they are urged upon us here as the grounds for sustaining the patent. They put forward, in a great variety of forms, claims for an electrical discharge device consisting of a tube with cathode and anode within it, with relation of parts and degree of evacuation (vacuum) such that the device is capable of operation with higher than ionization voltages in a range below saturation, substantially unaffected by ionization. Claim 2, which respondent selects as typical, reads:

"2. A discharge tube having a cathode adapted to emit electrons and an anode adapted to receive said emitted electrons, the tube walls being fashioned or shaped to permit the direct passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the electric field of said electrons substantially unaffected by positive ionization."

But this claim, as well as all others of the Langmuir patent, must be read in the light of the fact, fully accepted by the parties to this litigation, that electrical discharge devices such as the Fleming valve and the De Forest audion, patents on the latter of which expired in 1925, which were well known before Langmuir, comprise all the elements of the combination claimed except the presence within it of a high vacuum. It is conceded that if the requisite high vacuum be created in a De Forest audion, it becomes the high vacuum tube of the patent and is an infringing device if the patent is valid. The degree of the vacuum within the tube is therefore the crucial feature of the invention claimed. Langmuir, in describing in his patent the method of producing the device, says: "The evacuation of the device should be preferably carried to a pressure as low as a few hundredths of a micron, or even lower, but no definite limits can be assigned." In at least 13 of the claims, the device claimed is one in which the gas within the tube, or the pressure, is sufficiently reduced, or the vacuum raised high

enough, (all of which are synonymous), to produce the desired result, that is, a discharge unaffected by ionization when the tube is operated by the appropriate space current, which may be of higher voltage than that for the low vacuum tube.

The characteristics of the discharge named by the inventor in the specifications "in order to distinguish electron discharge devices made in accordance with my invention from the prior art" are the following: (1) gas ionization absent or negligible; (2) cathode not heated by the discharge; (3) no blue glow or visible evidence of discharge; (4) 3/2 power relation of current to voltage; (5) discharge independent of degree of vacuum within intended limit for particular tube; (6) regularity and reproducibility. But all these characteristics may be summed up in the simple statement that in the tube of the patent, there must be an absence of harmful ionization; and since, as already indicated, harmful ionization disappears when the requisite vacuum is attained, the device or structure of the patent is one in which such a vacuum has been produced.

That the high vacuum tube was an improvement over the low vacuum tube of great importance, is not open to doubt. Even though the improvement was accomplished by so simple a change in structure as could be brought about by reducing the pressure in the well known low vacuum tube by a few microns, still it may be invention. Whether it is or not depends upon a question of fact, whether the relationship of the degree of vacuum within the tube, to ionization, and hence to the stability and effectiveness of discharge passing from cathode to anode, was known to the art when Langmuir began his experiments. If that relationship was then known, it required no inventive genius to avoid ionization and secure the desired result by creating the vacuum in a DeForest tube or other form of low vacuum discharge device.

That this relationship was known was the fact found by the District Court and not challenged by the opinion of the Court of Appeals. In 1910 Lilienfeld, in a paper published in Annalen der Physik, Vol. 32, on "The Conduction of Electricity", made a complete and explicit disclosure of the essentials of all the structures and methods of the Langmuir patent. The paper described methods of obtaining the "extreme vacuum" desired by freeing electrical discharge devices of occluded gas in the manner al-

ready described and at the same time evacuating the tube. He described the space charge effect, not mentioned in Langmuir's original specification, but later recited in the claims of the patent, in the following language: "One can formulate more generally the conditions for high voltage and large current density as follows: The production of a state in which the volume density of the electrons carrying the current is as large as possible compared with the density of gas molecules in which there exists therefore a tendency for the formation of the maximum possible space charge in the path of the current." To one skilled in the art, this could only mean that increased effectiveness of an electrical discharge device, to which a suitable current is applied, could be obtained by raising the vacuum in the manner which the writer had described. He also stated that "from a definite maximum density of the gas downwards, the discharge phenomena are independent of the gas density in the region investigated", a statement equivalent to the fifth characteristic of the discharge in the Langmuir specification, namely, that it is independent of degree of vacuum within the intended limit for the particular tube.

Lilienfeld also deduced from meter readings and stated, the 3/2 power relation of current to voltage, as Langmuir later stated it in his patent. From this the conclusion is inescapable that Lilienfeld knew and stated, in terms which could be understood by those skilled in the art, that in a high vacuum the current produced is under control, stable, and reproducible; and, as he employed high voltages, that high power levels of the discharge may be obtained by the employment of a high voltage in a high vacuum tube. Space charge effect was also described by Lilienfeld in Physikalische Zeitschrift, in 1908, in which he pointed out that by raising the vacuum there is an increase in the number (volume density) of the negative electrons, and said: "The higher the vacuum, the greater the current density, the more pronounced this new kind of discharge becomes."

The very fact that Lilienfeld knew and described the methods of the patent for obtaining high vacuum carries with it as a necessary corollary that the device itself, apart from its functioning and use, is lacking in patentable novelty. Hence, invention, if any there be, is embraced in the discovery of the principle that discharges above ionization voltages can be produced without sub-

stantial ionization if the vacuum be sufficiently high, and the disclosure that the device of the claims constitutes suitable means for putting the principle into practice. But Lilienfeld, in his paper of 1910, disclosed that he obtained discharges free from the effects of ionization, as Langmuir testified in interference proceedings in the Patent Office, and that he accomplished this through the attainment of high vacua by the very methods later described in the Langmuir patent.

Fleming, the inventor of the Fleming valve, in a paper read before the Royal Society on the conversion of electric oscillations into continuous current by means of a vacuum valve, February 9, 1905, pointed out the possibility of creating "an ideal and perfect rectifier for electric oscillations" by enclosing within a tube a hot carbon filament and a cold metal anode "in a very perfect vacuum"; and he described a method of procuring the vacuum by exhausting the bulb while freeing it of occluded air. In his Patent, No. 803,634, November 7, 1905, he describes the method of securing a high vacuum within the bulb by freeing it of occluded gas by heating the bulb and filaments to incandescence and at the same time evacuating it. (He defined a high vacuum as one reduced to "one hundred millionth of an atmosphere", which is less than the 1/100 of a micron, the pressure in the tube of the patent; and in an article in "The Scientific American," supplement for January 20, 1906, on "electric conductivity of a vacuum", he disclosed not only that electrons are emitted by hot cathodes in a high vacuum, but also "that a high vacuum may be a very good conductor, provided the negative electrode is rendered incandescent.") Thus Fleming knew, and stated, the advantages of the high vacuum, its definition, and the method of procuring it. The state of the art and the progress of scientific knowledge in this field was accurately summed up in the statement of the law examiner in the Patent Office who passed on the Langmuir claims:

"It is apparent after a review of the record that there is no single element which is broadly novel in the assemblage of elements making up an electron discharge device of the character defined in the issue. An evacuated tube having therein an incandescent electron emitting cathode and an anode was old prior to the filing of Langmuir's application, and methods of attaining high vacua, sufficient to give a relatively pure electron discharge in a properly designed tube were also well known and available to persons skilled in the art."

In an article in "The Scientific American," supplement for January 20, 1906, on "electric conductivity of a vacuum," he defined a high vacuum as one reduced to "one hundred-millionth of an atmosphere," which is less than the 1/100 of a micron, the pressure in the tube of the patent; and he disclosed not only that electrons are emitted by hot cathodes in a high vacuum, but also "that a high vacuum may be a very good conductor, provided the negative electrode is rendered incandescent."

The narrow question is thus presented whether, with the knowledge disclosed in these publications, invention was involved in the production of the tube, that is to say, whether the production of the tube of the patent, with the aid of the available scientific knowledge that the effect of ionization could be removed by increasing the vacuum in an electric discharge device, involved the inventive faculty or was but the expected skill of the art. The question is not, as respondent argues, whether Lilienfeld or others made a practical high vacuum tube, but whether they showed how it could be made and demonstrated and disclosed the relationship of the discharge to reduced pressure, and how to reduce it. See *Corona Co.* v. *Dovan Corporation*, 276 U. S. 358, 384. That the production of the high vacuum tube was no more than the application of the skill of the art to the problem in hand is apparent when it is realized that the invention involved only the application of this knowledge to the common forms of low vacuum discharge devices such as the Fleming and De Forest tubes. Once known that gas ionization in the tube caused irregularity of current which did not occur in a high vacuum, it did not need the genius of the inventor to recognize and act upon the truth that a better tube for amplifying could be made by taking out the gas. Arnold, who was skilled in the art, and who had made studies of electrical discharges in high vacua, when shown a DeForest audion for the first time on November 14, 1912, immediately recognized and said that by increasing the vacuum the discharge would be sufficiently stable and have adequate power levels to enable the tube to be employed as a relay device in transcontinental telephony. The very fact that all of significance in the Langmuir improvement was obvious to one skilled in the art as soon as he saw the unimproved tube, as the District Court said, "lies athwart a finding of invention".

Respondent recognizes the force of this objection to patentability, but seeks to avoid it by insisting that the invention claimed is not as we have described it, but that "Langmuir's invention consisted in taking out [of the tube] the gaseous conductor upon which the prior art relied, and putting nothing [a vacuum] in its place." It adopts also the statement in the opinion of the court below, upon which its decision turned, "a vacuum, or, indeed, change of vacuum, isolated and standing by itself, is not the Langmuir invention, but it is a working tube in which all the elements, cathode, plate,

vacuum, so coordinate and interwork that the current flow is not affected by gas," a statement which, as we have already pointed out, takes no account of the scientific knowledge, available before Langmuir, that increase of vacuum in well known devices was all that was necessary to produce the desired result. Respondent elaborates, by saying that "in the practical prior art devices [that is to say, low vacuum tubes] the conduction of current depended upon gas ionization; the art, moreover, believed that unless there was enough gas to act as a conductor no current could flow and the tube would not work." It says that the high vacuum tube of the patent works on a different principle, that of the "pure electron discharge" and it was the recognition of this scientific truth and the adaptation of the device to it in which the invention consists.

But if Langmuir's invention is so to be defined, it is not the invention claimed by the patent. Respondent puts forth as sustaining this definition, statements in the specifications of the patent, to the effect that in the device of the patent, in which gas ionization is absent, the discharge is "distinct in its characteristics" from the described discharge taking place in an ionized gas, and again that it is "characterized by regularity and reproducibility with given conditions". But, while these and many other statements in the patent indicate that high vacuum was an effective means of producing in the old tubes of the art the stable current which could not be produced in the presence of ionization, they do not suggest any discovery of a scientific truth that essentially different principles control the discharge in low vacuum tubes from those which operate in high, other than that ionization, present when gas is present, has certain effects, notably on stability of current in a low vacuum, which is absent in the high, when ionization is absent, as Lilienfeld and others had disclosed.

If it were necessary to a decision we could not find that any such scientific truth is established by this record. Respondent, to support the contention, does not rely on evidence, but on a collection of more or less casual statements by various writers, made before 1915, to the effect that the gas or ionized gas of the low vacuum tube is a conductor. Before the development of the electron theory, "conductivity" of substances was a convenient expression for explaining the flow of electric currents. Fleming, in a statement in 1906, already quoted, referred to the high vacuum

as a good "conductor" if a hot cathode was used. The present tendency is to ascribe the flow of current from a hot cathode through both high and low vacua to the flow or discharge of electrons. Millikan the eminent physicist testified that this theory was generally accepted before 1912. Langmuir himself so explained the flow of current in a gaseous tube in his specifications. The known truth is that current flows through both low and high vacua and is unfavorably affected by ionization in the former; but that the flow is due to conductivity of the ionized gas in one and to something different, pure electron discharge, in the other, is not established by the evidence before us. There is some testimony to the contrary. Nor is our attention directed to anything which suggests that Langmuir thought there was such a difference, or relied upon it to remove ionization effects, rather than upon the simple expedient of removing the gas known to be responsible for them.

Even if the asserted difference were established, it is no more than the scientific explanation of what Lilienfeld and others knew, before Langmuir, of the effect of the high vacuum on the discharge, and the methods and devices for procuring the vacuum. It is method and device which may be patented and not the scientific explanation of their operation. See *LeRoy* v. *Tatham*, 14 How. 156, 174-6.

Only when invention is in doubt may advance made in the art be thrown in the scale to support it. If we were to assume that invention here was doubtful, we can find little to suggest that the high vacuum tube when produced satisfied a long felt want or that its present utility is indicative of anything more than the natural development of an art which has passed from infancy to its present maturity since Langmuir filed his application. There was little or no practical use for a high vacuum tube in 1913. The De Forest audion was not in general use and Langmuir did not see one until that year. The many amendments of Langmuir's application during its long pendency, disclosing his uncertainty as to what he had invented, and the exhibits in this case, constitute a history of the development of the art, which indicate unmistakably that the resort to the high vacuum tube for discharges above ionization voltages was but the adaptation to the natural development of the art, by those skilled in it, of the scientific knowledge which had been accumulated by investigation and experimentation. When the need became apparent, De Forest and

Arnold, as well as Langmuir, found ready at hand the knowledge which would enable one skilled in the art to satisfy it.

The court below, contenting itself with finding invention, said nothing of the finding of prior use by the District Court. We hold that this finding of the District Court was supported by the evidence and should have been given effect. As we have concluded that the Langmuir patent did not involve invention, we refer only briefly to the facts which establish prior use. In 1911 and until September of 1912, De Forest was in the employ of the Federal Telegraph Co. of California, then engaged in the commercial transmission and reception of radio messages, in which audion detectors as well as audion amplifiers were used. In July, 1912, De Forest sought and obtained a high vacuum in the audions used as amplifiers, and observed that when the vacuum was too low the blue glow effect occurred at from 15 to 20 volts. In order to secure higher voltages from the audions used as amplifiers and to procure the requisite high vacuum, he had some of the bulbs re-exhausted while super-heated. Before August, 1912, the Telegraph Company used De Forest amplifying audions at 54 and 67½ volts, which was possible only because he had exhausted the tubes of gas, which would otherwise have ionized at from 20 to 30 volts. The vacuum was lower than that obtained by later and improved methods; but the effect of high vacuum upon voltages above the point of ionization was then known, and the knowledge was thus availed of in practice. Whether De Forest knew the scientific explanation of it is unimportant, since he did know and use the device and employ the methods, which produced the desired results, and which are the device and methods of the patent.

Reversed.

Mr. Justice McReynolds concurs in the result.

with blue glow

A true copy.

Test:

Clerk, Supreme Court, U. S.